Interactive Cartoon Animation through Collaborative Storytelling: A Field Study

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ABSTRACT

We present a real-time multi-user interactive system in which children can use their drawings to create and perform cartoon animation spontaneously and collaboratively. With our system, children can control the movements and actions of the characters and tell stories like puppeteers. The interaction is simple and intuitive for children to learn and use. The preliminary results of this field study suggest that the system can effectively stimulate children's creative desire and imagination, encourage personal expression and exploration, and provide a way to communicate and cooperate with peers. Being low-cost, flexible, and robust, the system can be easily and quickly deployed in schools and other places while maintaining strong practicability and affordability that even extend into remote rural areas.

CCS CONCEPTS

• **Human-centered computing; Human computer interaction (HCI); HCI design and evaluation methods; Field studies**;

KEYWORDS

interactive cartoon animation, collaborative storytelling, children, squash and stretch

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1 INTRODUCTION

Before gaining the ability to express their inner world in spoken language, children have been able to share their observations, feelings, and thoughts of the world through drawings. Children's drawings are spontaneous, at will, exaggerated, dreamy, and sometimes absurd. They are the natural expression of children's minds and wisdom. Research has revealed that sequential drawings like in comics or storyboards can be deemed visual languages [3]. We wish to design an interactive system where children can use their own drawings to create animation. Animation typically is humorous, stylistic, and deeply loved by children. In addition to stimulating their artistic development, studies have shown that animation can encourage children to help others [5], engage children to study science concepts [12], and assist children to learn communication skills [15]. The software systems designed for children to create animation, however, often come with restrictions; for instance, usually the characters are inbuilt, the animation control is primitive, and the number of participants that can play simultaneously is limited [15]. On the other hand, the traditional animation requires highly professional skills and laborious effort to produce.

In the field of human-computer interaction, many researchers have shown great interest in how to use interactive systems for storytelling through computer animation. Sympathetic Interface [7] used a plush toy to direct a synthetic animated character. Video Puppetry [1] presented a video-based interface that allows users to create cutout-style animation by manipulating paper puppets. Shape Your Body [9] proposed to use one's body as a puppetry controller to animate a virtual silhouette. AnimaStage [11] utilized an actuated stage for users to animate passive crafts made from materials such as paper, wire, and cardboard. ShadowPlay2.5D [16] designed a sketch-based authoring tool to help users create 360-degree animation of classical Chinese poetry. Other research studied multi-user interaction to facilitate collaboration among children. POGO [4] developed interactive physical tools integrating gestural, visual, aural, manipulative, and material functionalities to help children create stories. TellTable [2] deployed a multi-touch interactive table that allows children to create characters and scenery based on elements of the physical world and through drawing. ShadowStory [10] let children create articulated digital characters and perform traditional Chinese shadow puppetry on a projection screen. In these works, however, the animations are generated by manipulating the specific joints of the character or via simple translation, rotation, and scaling. Consequently, the resulting animations are relatively stiff and monotonous, and lack the shape distortion of the characters during movements and actions, or squash and stretch, which is "by far the most important" of the basic principles of classical cartoon animation [14].

In this paper, we present a real-time multi-user interactive cartoon system that lets children plot stories, create characters, perform fantasy plays, and record their own voices, through collaboration with friends. Our system supports squash and stretch animation of the characters using the as-rigid-as-possible shape deformation [6]. With few constraints and rules, the interaction is direct and intuitive while being easy for children to learn and use. We emphasize creating a playful and enjoyable storytelling experience for children and, in the process, foster their imagination, creativity, cognitive development, and other personal skills such as communication and collaboration. Below, we briefly describe the system design and report the main findings in our field study.

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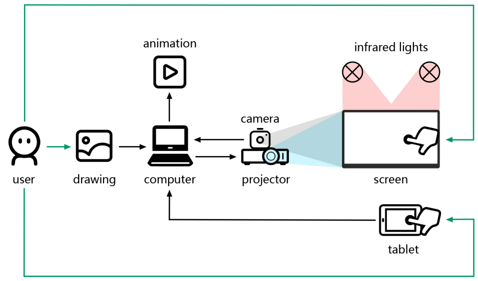


Figure 1: The system hardware consists of a host computer, a projector, a camera, a display screen, an array of infrared LED lights, and several tablets.

Figure 2: Scenes from the field study in the electronic information classroom at Shanghai Tongji Huangdu Primary School.

2 SYSTEM DESIGN

Our interactive cartoon animation system is designed to be low-cost and simple to construct, with an intuitive interface so that children can control the movements and actions of the characters without needing to learn complicated instructions. The system hardware consists of a host computer, a projector, a camera, a semi-transparent and diffusive display screen, an array of infrared LED lights, and several tablets; see Figure 1.

To manipulate the shape deformation and movements of the character, the user can: 1) touch and drag it directly on the display screen, or 2) control it remotely via a tablet. For direct character operating, a projector rear-projects the images of the animation characters and the scenes on a semi-transparent and diffusive display screen. Mounted above the projector, a camera with a filter blocks visible light but allows infrared light to pass. The camera captures the user's finger contact reflected by the infrared LED lights on the display screen. The host computer then processes the camera data stream using CCV (Community Core Vision) solution and sends the finger-tracking results to our animation program via TUIO packets. For remote character operating, we use TuioPad to track and send the user's finger touch positions with the tablet to our animation program in the host computer. The tablet's IP address and port number are used to pair with the animation character it operates. To show which characters users are currently operating, each tablet is assigned to a unique color. When the user's finger taps a tablet, a dot of its corresponding color will appear on the display screen, showing the current touch position.

3 FIELD STUDY

We conducted a three-day field study at Shanghai Tongji Huangdu Primary School. The participants were students from the first to the third grade (20 girls and 10 boys), and the location was chosen to be the electronic information classroom; see Figure 2. We set up a camera to record the children's interaction activities around the installation. The animation displayed on the screen, together with the children's voices while they acted out the characters, was also recorded. Three researchers were on-site to observe, take notes, and interview with the children. Our research focused on observing children's natural interaction behavior patterns, while assessing the usability of the system.

When we first deployed the interactive animation system in the classroom, this new installation quickly became the topic of the children's conversation. The idea that they could turn drawings into animations to tell their own stories made them curious and excited. In the first step, the drawings were scanned into the host computer, where elements in the drawings were separated and extracted into characters and background scenes. We used 3ds Max to generate a triangular mesh for each character. For most characters, a triangular mesh consists of about 300 evenly distributed vertices would result a smooth and responsive shape deformation.

We have designed five basic character operating gestures: 1) alternating two-finger tapping, for the character walking and running; 2) single-finger swiping, for the character turning around; 3) one-finger fixed, another finger dragging, for the character's local deformation; 4) multi-finger dragging, for the simultaneous deformation and movement of multiple parts of the character; and 5) single-finger dragging, for the translational movement of the character. The children could typically tell which characters they were operating in seconds (while in remote mode using tablets) and master the character operating gestures in just a few minutes. Compared with the tablet, the display screen seemed to be more preferable by children for the character interaction. Even with the tablets in their hands, some children would come forward and touch the display screen. One problem, however, was the simultaneous use of the direct and remote controls. The users who were operating on the display screen would sometimes block the views of those operating on the tablets.

The entire field study was open, and all children who wanted to try our system were welcome. During the deployment, some children came every day, some came from other classes, and some returned to the classroom after "a few bites" for lunch. Overall, the children enjoyed playing with our system and, in particular, showed a sense of pride when animating their created characters. After a performance, many children would review and share the stories they just created with classmates who had not watched performance. Some children asked for their animation to be replayed by the system, so more students could see the works. Several children left their contact information and hoped that we would later send them the animation they created.

By theme analysis, we found that making cartoon animation through collaborative storytelling had a significant impact on children's behaviors in the following three aspects.

a) War of the Supermen. b) The Girl and Two Puppies. c) The Three Princesses. d) Hide and Seek.

Figure 3: Stills from the children's animations.

3.1 Imagination and Creativity

The children had peculiar senses for the theme of the story, the style of the character, and how the characters should operate. Some of the characters created by the children came from their daily experiences, such as girl in a straw hat, a girl walking a dog, and girls with twist braids and double ponytails (Figure 4a). Other characters were derived from Chinese mythical stories, such as Monk Tang in "War of the Supermen" (Figure 3a), or from classic cartoons like Mickey Mouse in "The Girl and Two Puppies" (Figure 3b). The children carefully designed exclusive hairstyles, clothes, and shoes for the characters. We noticed that many characters drew by children had smiley faces, including the puppy, bunny, jellyfish, and sun characters. In one drawing, the door and the big tree were smiling. The children also invented some peculiar behaviors for their characters that were not common in daily life. For instance, when the characters first met in the story, the children would make them greet with each other, such as by waving their arms. However, in "The Three Princesses" (Figure 3c), each princess had long hairs, so the girls chose to fiddle and wave the princesses' hairs to say hello. Interestingly, the greetings often extended to parties beyond the screen, sometimes between the characters and the performers, and sometimes between the characters and the audience.

The Monk Tang that was created by a boy differed greatly from the Monk's traditional courteous, gentle image. Although some elements related to the traditional image were vaguely apparent in the drawing, such as the Ksitigarbha hat worn on the head, the boy's strong and brave Monk Tang had amazing fighting power. The Monk Tang's hands were originally drawn resting on the hips. Until the animation performance, the boy found that he could not independently control the movement of the character's hands (the program's fault). To adjust, he readily added a pair of wings to the Monk, which not only solved the problem of animation control but also made the Monk Tang character "more handsome", as the boy proudly told the researchers during the interview. It is noted that drawing a nonexistent object in response to representational change is considered to be a measure of cognitive flexibility, which is regarded as core executive skills critical for children's cognitive development [8].

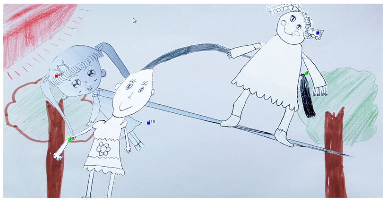
We also noticed that, in the animation stories created by the children, every character was a protagonist. Every character was involved in the story from beginning to end. It was simply difficult for children to let their characters remain stationary for more than a few seconds, and at any moment, someone's character might become the focus of attention. The children also seemed to have no prejudice toward the characters, whether it was a princess or a jellyfish, a superman or an ordinary person. One child created a jellyfish and invited "other people" to play with it. One child even wanted to play the role of a football, an inanimate object. The system provided the children with free and absolute control over the characters. Anyone could touch the screen to change the course of the story, thus allowing any character to take the lead in the animation.

3.2 Spontaneity and Exploration

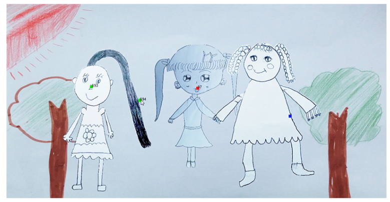
Most children preferred not to have a fixed script before the performance, and most of their stories were told without rehearsal. Almost all performances were improvised, and the children seemed to do whatever came to mind in the moment. The simple and direct interface of our system makes the interactive animation essentially a free-flowing fantasy play. With few constraints and rules, the interaction is easy to learn and use. There are no restrictions for the characters, objects, and scenes to be inbuilt, for the movements and actions of the characters, and for the number of participants that can play simultaneously.

The squash and stretch character shape deformation particularly aroused the children's curiosity and interest in experimentation. In "The Three Princesses", right in the middle of house playing, on a whim, the three girls wanted to go to the sky to play fairies together. So one girl stretched her princess skirt and transformed it into a beautiful kite. Then she gave a gentle blow, which turned into a big wind in one breath, and flew up into the sky with the other two little princesses. The flying of the princess kite into the sky was not a straight and stiff translation, but rather occurred with gentle shape deformation, as light as a silk scarf. In "The Blue Ocean Princess" (Figure 4b), a girl accidentally tangled with the jellyfish's tentacles, which made its body bounce like a spring. "Help, I'm being trapped!" she cried out. Another girl quickly stretched her skirt into a knife, and spun it to cut open the jellyfish's tied tentacles. Occasionally, some character's shape deformation would collapse due to the program bugs, but these errors often made the children more excited and seemed to bring them unexpected fun.

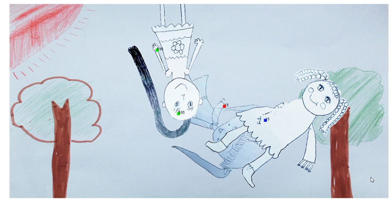
Our system allowed the children to extract different elements from the drawings and then rearrange and compose those elements. One group of the children, when assigning roles, found that there



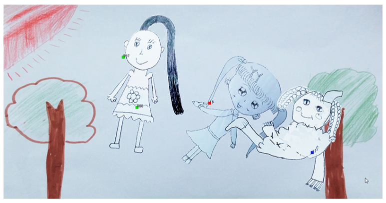
The three braids girls often jump rubber band in the park.



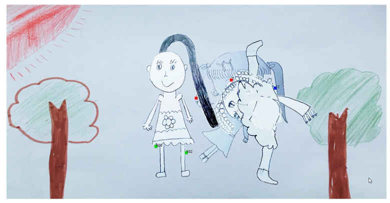
One day, the single ponytail girl asked: "Can you do any stunts?" Everyone said no.



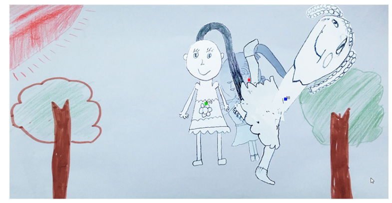
"Let me show you a somersault," the single ponytail girl said and made a circle in the air.



The double ponytail girl followed successfully. "I learned it!" The twist braid girl, however, fell down and she did not know what to do.



But she was not a girl who gives up easily. She kept adjusting her posture, standing on one foot and raising the other.



"I succeeded too! I learned to do the split while standing!"

a) The Braids Girls.

On a fine day, the Princess was playing with Jellyfish on her doorstep. Fengfeng and Nunu went out for a walk.

They found the Princess fainted on the other side of the ocean. Fengfeng's dog also noticed, and started barking.

Jellyfish thought the dog was going to bully the Princess and stretched out her long tentacles to drive him away.

Nunu decided to attract Jellyfish's attention and let Fengfeng save the Princess.

After the Princess recovered, she personally came to Fengfeng and Nunu's house to thank them.

They had a good time playing together. Since then, there has been another pair of good neighbors who loved each other on the prairie.

b) The Blue Ocean Princess.

Figure 4: Excerpts from the children's animated stories.

were not enough characters for everyone. In response, the children readily extracted the jellyfish in the background scene to form a dynamic layer, making the jellyfish become a character in the story as well. There were also some children who were not satisfied with confining the scope of a character's activities within the screen frame. Those children would intentionally try to drag the character out of the screen. Upon discovering that the system supported this movement, the children concealed the characters off screen and improvised an animated story of hide and seek (Figure 3d). Notably, some children extended this exploration beyond the interactions supported by the system. One child deliberately walked behind the screen while other children were performing, for instance, in an attempt to shadow herself into the story via the projector (Figure 2, top right). This action was unexpected. It would be interesting to experiment interacting shadow with the animated characters in the future [13].

3.3 Empathy and Friendship

In telling their stories, the children became lively and exuberant performers. They would sometimes suspend the control of the characters and perform with their own bodies first. When immersed in the performance, the children would often refer to each other's characters by their own real names, project themselves onto the roles being played and treat the characters as themselves. While animating the movements and actions of the characters, the children also liked to dub the characters and used a variety of sound effects to assist with the telling of the story. Such behaviors also happened to the audience, who would often let them be connected to the story on an emotional level. In "The Girl and Two Puppies", when the bunny's ears were pulled out of shape, the audience anxiously stopped it. One audience member even reached out trying to interrupt the performer's control of the bunny character.

Many children liked to discuss stories, draw characters and scenes, and make animation with close friends. Some children took the initiative to invite those who had not brought their own drawings to play together, hoping to make new friends through collaboration, such as when the boy who created Monk Tang wanted to find a Monkey King to perform with him. When creating stories, most children would choose plots to make friends and help each other. Even if there were occasional episodes of the character fighting, such interludes did not affect the harmonious and happy atmosphere among the children. When it was not their turn, the children would sometimes participate in other ways. One child brought a colorful scene design but did not get a chance to perform, so she explained to everyone around her what would happen in every castle and every forest in the scene.

Throughout the performance, the audience also played a unique role. They cheered from time to time and made comments. Occasionally, suggestions from the audience would lead to an impromptu performance. Every now and then, some overly eager members in the audience would even reach out and touch the tablet in the hands of those who were operating. Some children would readily accept these "helps", while the others would immediately push back the uninvited hands. Later, the children learned to negotiate, and almost every child who negotiated was finally given a chance to participate.

4 CONCLUSION

We seek to retain children's original ideas to the fullest extent possible. The system returns the initiative of animation making from adults to children, providing them a fantasy play platform for free expression and spontaneous creation. With interactive animation, new ideas and possibilities continue to collide through active communication among the children, inspiring more imaginative and creative stories. By playing and projecting themselves onto different roles, children begin to understand and empathize with different characters, thus learn to see things from others' perspectives. In a relaxed state of playing through the real interactions, the children's teamwork ability is enhanced, and the bonds of friendship are strengthened as well.

Although the resulting animations by children are not comparable to those of professional productions, we did not develop the system aiming to make the two equal. We believe the most precious aspect is not the final animation, but rather children's discovery of life and the world, the fun and joy of creating and telling stories together, and the friendships developed among peers. Perhaps in the future we may use this system in family environments, helping parents better communicate and interact with children by making animations together. School teachers may also use this system in the classrooms to engage students and motivate them to participate in lessons through the joyful activities of interactive animation.

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